SUPPLY CHAINS OF MINERAL RAW MATERIALS AND MONTANISTIC TOURISM

Ctirad SCHEJBAL [1]

[1]*Institute of Geological Engineering, Faculty of Mining and Geology, VŠB-TU Ostrava*
17. listopadu 15/2172, 708 33 Ostrava-Poruba, Czech republic, tel. (+420) 597 323 578
e-mail ctirad.schejbal@seznam.cz

Abstract

Supply chains in the mineral raw material industry take different forms depending on requirements, the placement of resources and points of consumption, and the nature of geological, morphological and botanical landscape type. Hitherto, in the context of montanistic tourism, the attention is paid primarily to the objects associated with the exploration and exploitation of mineral resources. Professionally and touristically, processes of transport of mineral raw materials and products of their processing can be interesting. Therefore, during the selection, development and implementation of montanistic tourism products, it will be useful to focus on these parts of a supply chain, especially if they are implemented in areas with high levels of geodiversity and biodiversity.

Key words: Supply chains in mineral industry, transportation of mineral raw materials, montanistic tourism, and mineral industry supply chains

1 INTRODUCTION

The basic factors determining the logistics of utilization of mineral resources involve mainly the heterogeneous spatial distribution of mineral accumulations, the impossibility of their relocating and distance from the place of processing and consumption. Further factors can be added such as both increasing requests for necessary mineral raw materials, and the effect of new production processes, new types of products and growing efforts to use previously used materials, which expresses the motto of ”recycling, remanufacturing, redesign, rethink” (Interagency Working Group 1999 Washington).

It all basically defines solutions of supply chains in the sphere of mineral industry and has the impact on the content and organization of montanistic tourism. This specialized type of tourism is oriented on subjects that relate to the discovery (geological survey), exploitation (mining and quarrying) and processing (treatment plants, smelters, and following industries) of mineral resources. Transportation processes of extracted minerals and materials obtained from their treatment yet remain aside of interest. These processes realized by means of road, rail, product pipeline and shipping, are in many cases very interesting, especially when taking place in areas with high geodiversity and biodiversity, i.e. in geological, morphological and botanical varying or even extreme landscape types [1]. They may represent an attractive content of specialized tourism focused on the cognition and understanding of principles and procedures of materials transport, which in many cases can be very complicated.

In this concept, a certain analogy can be seen in those tourist products, which emphasize the actual transport route. An example could be a sightseeing train journey (e. g. Glacier Express and Bernina Express) or cruises to the Mediterranean, the Caribbean, etc. One should not forget the principles of one of backpackers who expresses the slogan “All you've got to do is decide to go and the hardest part is over. So go!” mentioned in guidebooks of Australian-based editions of Lonely Planet by Tony Wheeler called “the patron saint of backpackers“[2]. In all these cases, the transport itself is the target, or if you like, the main content of tourism.

2 PRINCIPLES OF SECURING MINERAL RESOURCES

The whole problem of ensuring the energy and material needs of man can basically be imagined as a distribution network with containers (manufacturers of stocks of raw materials, energy producers, industrial companies, and shops) from the sources of raw materials to the final consumer (Fig. 1). In case of failure (loss of production or transport, increase, decrease or interruption of power), problems may occur up to the collapse of the entire network. Similarly, any change to the source (e.g. termination of mining operations) or final consumption must be accompanied by a change in the entire distribution network. For example, if we stop mining coal and fail to be able to provide import, then after the stocks are exhausted, thermal power plants stop

to produce electricity and we cease to make light, heat and so on. Or, conversely, if we do not use electricity, its manufacturing must immediately stop after filling the buffer reservoir.

The basic components of supply chain solutions in the raw material industry reflect the following scheme.

Fig. 1 Procedure of supply chain solutions

Free trade with raw materials in the context of real options and economic scenarios of each state is and will be a necessary condition for further development. We must realize that, in fact, it is not a new problem, as it is the same as with many natural materials traded by our ancestors. With the development of the industry, the focus of trade began to change rapidly, both at national and international levels. Growing industry needs more fuel and raw materials. Products had to be transported to customers, either for further processing or for direct use. This need caused changes in existing supply systems, which in addition to changes in the means of transport began to interconnect within countries or continents to create a more extensive, complex and sophisticated systems [3]. Currently, the supply systems in the sphere of resource industries are increasingly interconnected, which is partly the result of changes in the dislocation of acquired and newly discovered fields of mineral raw materials and focal points of their consumption, as well as processes of globalization.

3 MINERAL INDUSTRY SUPPLY CHAIN

In securing the supply chain from source to user for a given object, its transportation implies to choose the appropriate transport equipment, route / routes, storage and terminal / terminals. Specific solutions are different and in principle must comply with user's requirements, spatial relationships between resources and users, and existing or anticipated traffic routes.

The selection of a suitable transport system depends primarily on the remoteness of resources and the place of consumption. From the possible routes, it is necessary to select those that meet the cost, time and organizational constraints. Therefore, the system configuration can vary from simple to complex, with more sources and users.

In case of raw materials having only local value such supply chains are simple. This means that due to their lower cost they cannot be transported over long distances. For this reason, the area of their consumption is substantially adjacent to the sources such as the majority of deposits of sand, gravel or crushed stone. The supply chains of mineral resources with common value, or raw materials, which have the character of critical and strategic materials, are characterized by different arrangements. This follows from the fact that their value significantly exceeds the cost of transportation and handling. This relates to energy resources (coal, oil, and natural gas), all ferrous and base metals, precious metals, rare earth metals, precious stones, etc. Just this type of supply chains is interesting for designing and implementing products of montanistic tourism [4].

4 UTILIZATION OF SUPPLY CHAIN MONTANISTIC TOURISM

Until now, the montanistic tourism products focused on surface and underground mines, surface equipment of historical and current mines and preparation plants. In several examples, I would like to show that a supply chain or parts thereof can be professionally and touristically interesting, in particular when the transport system of mineral resources is quite complex and goes through geological, geomorphological and botanically interesting landscape types. Such cases often occur in areas that are difficult to access, and therefore poorly equipped with transport routes.

A classic example can be the utilization of one of the world's largest porphyry copper and gold deposits – Ok Tedi in the State of Papua New Guinea. The deposit is located in the tropical mountain environment of the Star Mountains at an altitude of around 2,000 meters. The region is exposed to high rainfall and frequent earthquakes, which brings serious problems in mining activities. The ore from the opencast mine is transported with dumpers to a mill. The ore concentrate is further transported in a form of aqueous slurry through 157 km long pipeline to the town of Kiunga where it is dewatered and stored in the port. After loading on special boats with a shallow draft, the concentrate is transported down the Fly River to the 900 km away Umuda port of the island in the river delta in the Gulf of Papua, Coral Sea. After transferring to vessels, the ore concentrate is shipped to customers in Japan, Korea, India, Germany, and the Philippines (Fig. 2). Every transfer is equipped with tanks to ensure smooth operations of the chain.

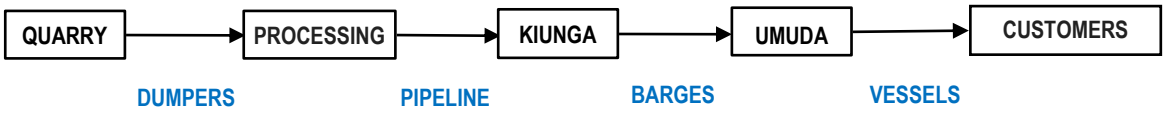

Fig. 2 Supply chain of Ok Tedi deposit (Papua New Guinea)

For the realization of montanistic tourism, the product must be, for both professionals and laymen, a technically and landscape attractive route, which would include a tour of the quarry, processing plant, the section of pipeline transport, port facility in Kiunga and the path along the Fly River through the jungle to the seaport.

A complicated supply chain with four types of transport means and three reloadings is implemented in the extraction of coal deposits at the Stockton Mine in the Buller Coalfield on the South Island of New Zealand (Fig. 3). The tectonically disturbed deposit of high-quality coal is at an altitude 500-1100 meters at a distance of about 8 km from the coast of the Tasman Sea. The extracted coal is transported with dumpers to a sorting plant and from here with 8 km long cable car to the terminal in Ngakawau. The coal is further transported by train through the Southern Alps and must overcome significant differences in altitude (more than 900 meters). The length of "Coal Route" Ngakawau - Lyttelton Port in Christchurch on the east coast is 350 kilometres. The coal is finally exported on vessels to steel producers in Japan, India, China, South Africa, and Brazil.

Fig. 3 Supply chain of Stockton Mine (New Zealand)

The entire route, including the tour of coal mine, cable car route, Ngakawau handling facility and the coal route to Lyttelton, is professionally and touristically attractive because it includes both montanistic objects and technically demanding transport equipment (a large number of tunnels and bridges) as well as very interesting and different landscape types, from coastal plains and a fern jungle on the coast of the Tasman Sea, through the alpine landscape of the Southern Alps, mountain plains with feral rivers to the agriculturally productive Canterbury lowlands to the east.

The supply chain from the Carajás deposit in the State of Pará in Brazil is also notable [5]. This deposit currently represents the largest accumulation of quarrying high quality oxide of iron ore with an average metal content over 65 %. In addition to the tours of surface mine where the automobile transport, for reasons of efficiency and especially environmental protection, is replaced with sliding belt conveyors, the transport part from the deposit to the port of Ponta da Madeira on the island of Sao Luis in the State of Maranhão is touristically very attractive as well. The 892 km long route with 61 bridges goes through the Amazon rainforest and crosses several rivers. Besides freight railroads, it provides passenger transport as well. Along the route, 120 million metric tons of ore and 350,000 passengers are transported annually. Each freight train with a length of 3.3 km and 330 wagons carries 53,000 tons of ore.

From the viewpoint of montanistic tourism, supply chains in areas with extreme conditions, i.e. extreme climatic zones such as tundra, or in extreme altitudes, e.g. in the Bolivian, Peruvian, or Chilean Andes are of great interest. An example can be the supply chain of diamond mines such as Diavik, Ekati, Lupin, and Jericho in Canada, which are located in tundra of the Northwest Territories [6]. It is an area of permafrost, the uppermost portion of which, in the short summer, thaws and turns into impenetrable swamps and lakes. Supplying is possible by air or by ice roads built in winter, which lead partially over frozen lakes. These ice routes are together with a mine visit very interesting. Yellowknife, the capital of the Northwest Territories, is accessible by highways and preferably by air. As an example of a very interesting transport system at very different altitudes, the road transport of Pb-Zn concentrates from the San Vicente Mine in the Peruvian mountainous jungle on the eastern slopes of the Andes through the eastern Cordillera to the smelter and refinery in La Oroya can be mentioned as well as the transportation of products from these points over the Central Cordillera by road or rail to the port of Callao in Lima [7]. The altitude differences are large. The San Vicente Mine is located about 1,500 meters above sea level. The highest point of the road over the Eastern Cordillera is about 4400 meters. The city of La Oroya is located in the valley of the Altiplano at an altitude of about 3700 meters. A very spectacular route from La Oroya to Callao leads through Ticlio Pass at an altitude of 4818 m in the Cordillera Central and then through Rímac River gorge to the ocean in the port of Callao. Further action in the metallurgical complex of La Oroya is a problem due to lack of ore concentrates and particularly from environmental considerations. Therefore, it was put up for sale, and if the sale is unsuccessful, it will be liquidated. But still the described transport system will be in terms of montanistic tourism very interesting. For a full enumeration of methods for

the transportation of raw materials, which can be interesting when designing products of montanistic tourism, the transportation pipelines, applying mainly in the transport of liquid and gaseous hydrocarbons, can be mentioned.

As one of the Alaska tourist attractions, the trans-Alaska oil pipeline that runs from the Arctic Ocean to the south to the port of Valdez is worth mentioning. About 1,300 kilometers long pipeline provides the transportation of crude oil extracted in the vicinity of Prudhoe Bay to the Valdez terminal with 18 storage tanks. The crude oil is loaded onto tankers and shipped to refineries. A very intricate morphology of the territory complicated the construction of the pipeline, which lasted three years, because the route had to overcome significant differences in height (e.g. Brooks, Alaska and Chugach Mountain Ranges), rivers (Yukon River and more than 800 streams) and the Denali fault, a seismically active fault with frequent manifestations of earthquake. Due to mass migration of herds of caribou and moose, it was necessary to build underground parts of the pipeline as crossings. The construction of the pipeline and the parallel Dalton Highway (haul road) required 60 million cubic meters of gravel for the insulation of the underground parts of the pipeline and the foundations of the pillars supporting the aerial parts of the pipeline. A significant problem stemmed from the fact that it was an area of permafrost and climate-exposed territory, with temperature variations from -50 to + 30 °C. For these reasons, the pipeline is suspended on deeply based pillars with a cooling system and its route runs very irregularly. That is why the pipeline is attractive in terms of montanistic tourism. Often there may be cases when the production company needs more kinds of minerals for its operations provided from different sources; or the producing result may be a greater number of products. In such cases, the supply chain is more or less complicated. Typical examples can be metallurgical and electrical utilities. For example, the metallurgical company ArcelorMittal Ostrava needs for the production mainly iron ore imported from the Krivoy Rog area in Ukraine and the Kursk magnetic anomaly area in Russia as well as black coal from mines of the Czech part of the Upper Silesian basin and carbonate rocks from the Štramberk deposit in Moravia. In case of imports of iron ore, the optimization of transport routes is needed. The products include iron slabs, sheets, tubes, and various engineering, steel and foundry products. In the 19th and early 20th centuries, the surface transport of coal mined in the Svatoňovice district of the Lower Silesian basin was very notable (Fig. 4) [8]. The coal was transported with regard to the morphology of the terrain on the slopes of the Jestřebí hory Mountains from adits and pits using the system of a narrow-gauge horse rail and incline tracks with a braking machine (so-called bremst – blue arrows in Fig. 4) to 4 km long horizontal horse track from the Xaver Mine to Malé Svatoňovice for further processing in coke and briquetting plants and expedition at the train station.

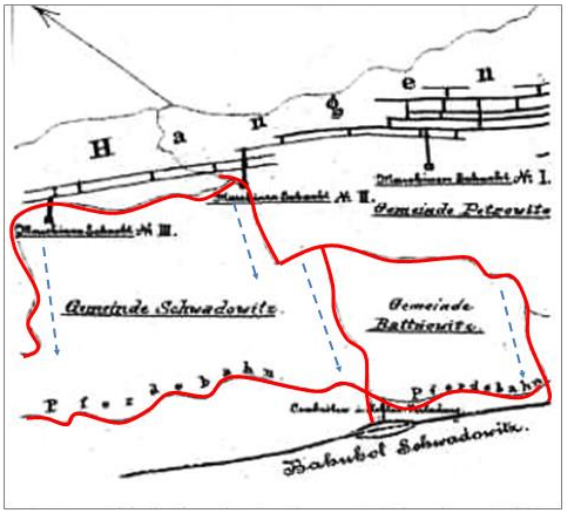

Fig. 4 Mining activities of old Svatoňovice mines with horse rails and bremsts in 1875 (Studánka 2010, 4, modified)

The thermal power plant Prunéřov in northern Bohemia uses for its production the coal imported from a distance of about 10 km by a railway siding from the surface mine Nástup Tušimice, the water pumped at the station Mikulov from the Ohře River, and the limestone for desulphurization transported by rail from a distance of over 140 km from the surface mine Čeřínek of the Lomy Mořina company in the Czech Karst.

As main product, the plant produces the electricity, besides the warm water supplied to nearby towns and construction and building materials, which are the product of combustion and desulphurisation processes, such as gypsum, ash and slag, or mixtures thereof (Fig. 5).

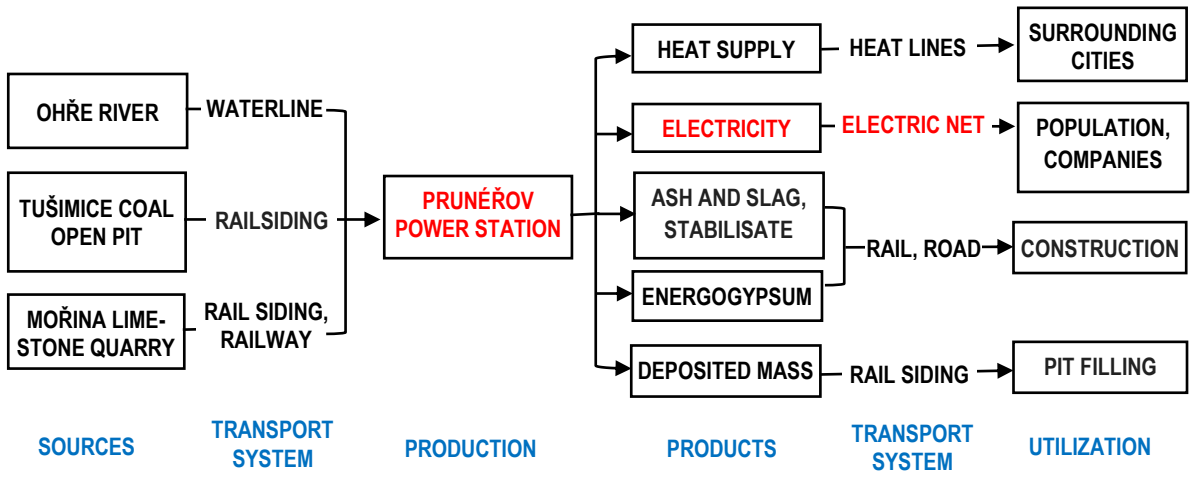

Fig. 5 Supply chain of Prunéřov power plant (Czech Republic)

5 CONCLUSIONS

There is no doubt that the logistics of exploitation of natural mineral resources is an important and complex problem. Corresponding supply chains, therefore, may take different forms, from local to global. Therefore, their solution requires the undivided attention of all components that are involved in the trade in raw materials.

From the viewpoint of montanistic tourism, in the selection, design and realization of offered products, attention should be paid to the whole supply chain, not only the initial phase connected with mining operations, therefore, interesting technotopes (Schejbal, 2015 b). As has been shown in several examples, the actual stages of carriage in geological, geomorphological and geobotanical spatially differentiated terrains, with significant geotopes and ecotopes, may be interesting for both professionals and for interested lay people. The benefit of the that there is a significant number of touristically interesting supply chains in the mineral raw materials industry. Not only their complexity will be crucial, but especially the character of geochores and biochores of the environment in which they are realized.

REFERENCES

[1] SHEJBAL C. Diversity as a general basis of tourism – system approach. *GeoScience Engineering*. 2015, **61,** 18-25.

[2] WHEELER T. *Across Asia on the cheap: a complete guide to making the overland trip*. Paddington, N.S.W.: Lonely Planet, 1973.

[3] SHEJBAL C. Proposal for Classification of Diversity Structure in Geoscience and Montanistic Tourism. *Procedia Earth and Planetary Science*. 2015, **15,** 649-655.

[4] SMITH C. LAURENCE. *The World in 2050: four forces shaping civilization's northern future*. New York, N.Y: Plume, 2011.

[5] Carajás Railroad: The path our wealth runs on. Document Moved [online]. Copyright © 2017 [cit. 30.09.2017].
Available from: http://www.vale.com/brasil/EN/initiatives/innovation/carajas-railway/Pages/default.aspx

[6] Tibbitt to Contwoy to Winter Road. Project description report [online]. Department of Indian affairs and Northern Development Yellowknife, NT. [cit. 12.8.2017].
Available from: http://pubs.aina.ucalgary.ca/gran/54890.pdf

[7] U.S. Geological Survey, 2015, Mineral commodity summaries 2015: U.S. Geological Survey, 196 p., http://dx.doi.org/10.3133/70140094.

[8] Bremsts or horse tracks. *Studánka*. 2010, **XVIII**, 5 p.